

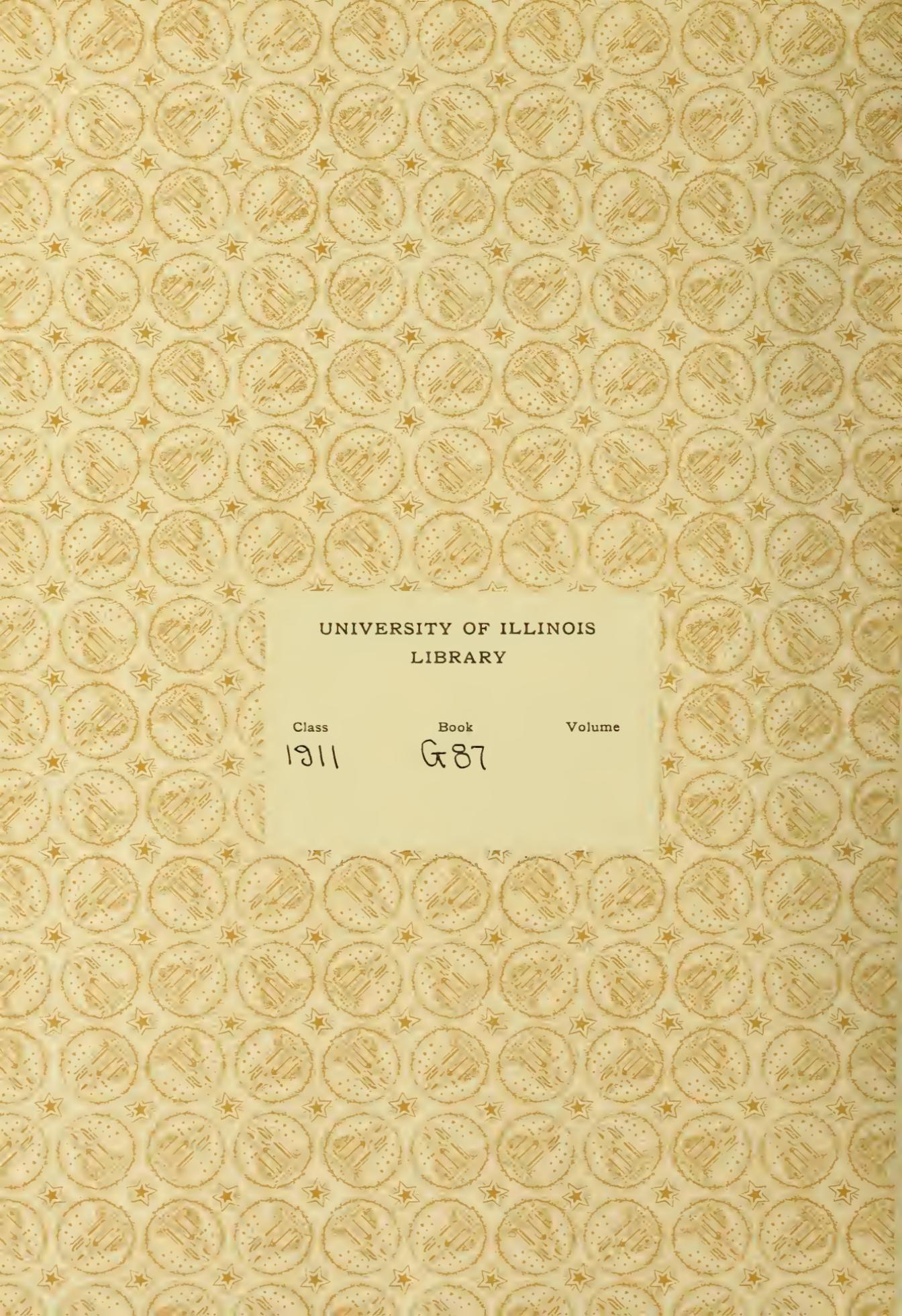
GRIGSBY

Modern Methods of Street Cleaning

Civil Engineering

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MODERN METHODS OF STREET CLEANING

BY

MARION WILLIAM GRIGSBY

THESIS

FOR THE

DEGREE OF

BACHELOR OF SCIENCE

IN

CIVIL ENGINEERING

IN THE

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I recommend that the thesis prepared under my supervision by MARION WILLIAM GRIGSBY entitled Modern Methods of Street Cleaning be approved as fulfilling this part of the requirements for the degree of Bachelor of Science in Civil Engineering.

C. C. Wiley
Instructor in Civil Engineering.

Recommendation approved:

Ira O. Baker
Head of the Department of Civil Engineering.



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INTRODUCTION.

The work of street cleaning is the oldest and possibly the least developed branch of municipal sanitation. The first attempts along this line date back to the earliest antiquity. At that time there was very little street pavement, the improvement being confined principally to private driveways, etc. The cleaning of these was paid for by the owners, who were desirous of keeping the pavement swept for the sake of appearance, rather than for sanitary reasons. As civilization developed the amount of pavement greatly increased, but the primary reason for cleaning it remained the same. This condition, together with the fact that the work was done by slave or poorly paid labor, accounts for the slow developement of suitable methods of cleaning.

In recent years, however, the rapid increase in the number of paved streets, and our greater demand for sanitation, has greatly increased the amount and the necessity for doing this work. Owing to the many miles of pavement in every city, to the amount of street traffic, and the great amount of money required for cleaning the streets, it has been necessary to devise methods which are rapid, thorough and economical. In the last twenty or thirty years many methods and appliances have been introduced which have greatly improved the character of the work. But as yet very little is generally known concerning the correct principles of street cleaning. Although every citizen is a competent critic of the results, few are willing to make a study of

the problem to understand its difficulties, or are competent to devise the practical measures of improvement required.

For these reasons efficiency in operation is less in street cleaning than in most other sanitary undertakings, but with time this defect will doubtless be overcome. A constant effort should be made to improve upon the methods employed, to keep accurate account of the ways in which the money is spent, and to accomplish the results which the citizens expect.

Therefore a study of the various systems, machines and implements employed and the results obtained by their use will doubtless give valuable information in regard to the correct principles of street cleaning.

ARTICLE 1.

STREET DUST AND DIRT.

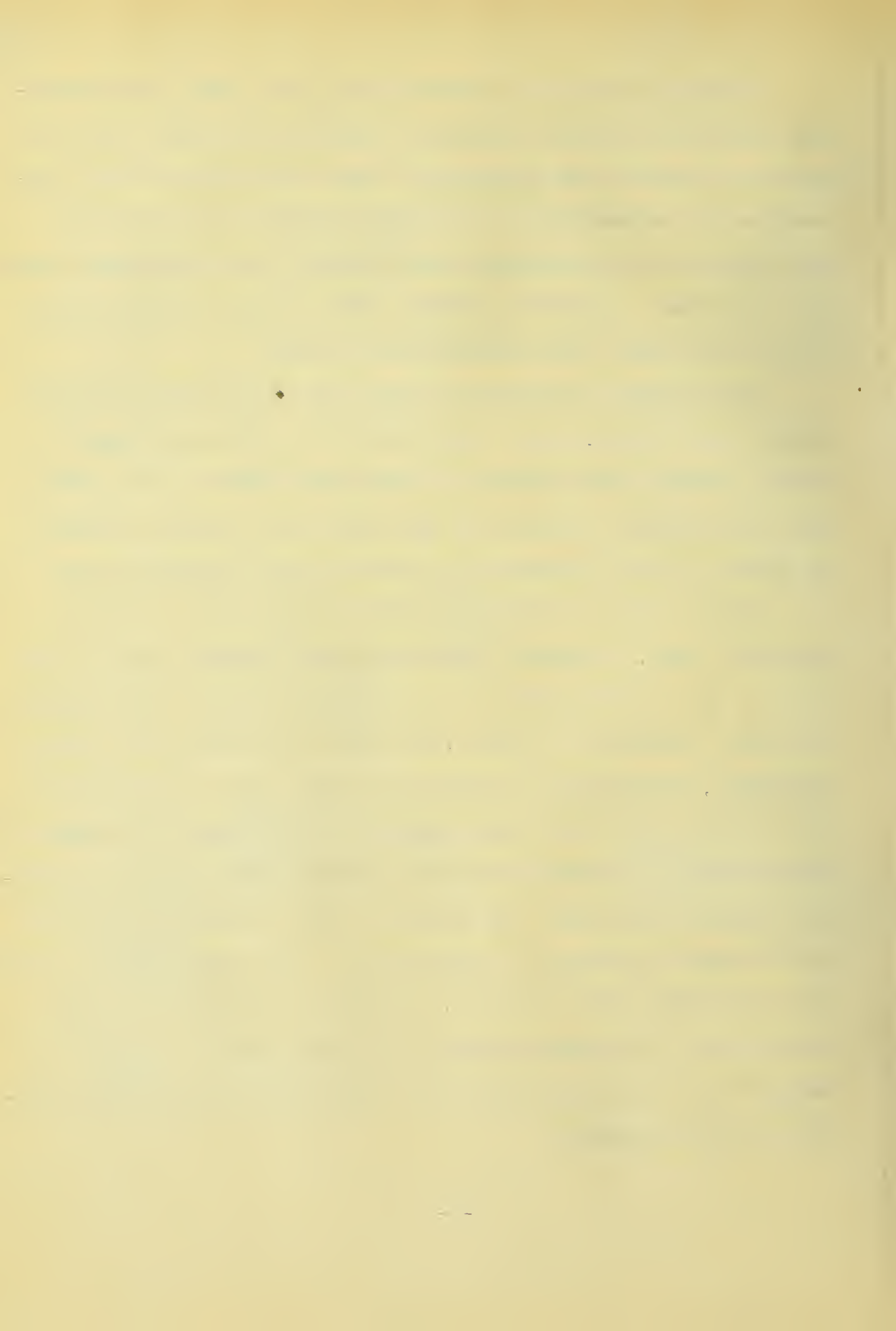
The dirt that accumulates on the streets comes from a variety of sources some of which are controllable and some of which are not. The controllable sources of street dirt are: (1) refuse swept or thrown upon the streets from buildings, (2) refuse such as paper sacks, banana and orange peelings, printed matter, etc., thrown on the streets by pedestrians, (3) refuse spilled from passing vehicles, (4) detritus from building operations and from repairs of streets and underground work.

The uncontrollable sources of street dirt are principally of two kinds, the dirt carried onto the paved streets from the unpaved streets, and manure. The former is worst in wet weather when the unpaved streets are muddy and wagons coming from them onto the paved streets will carry a very considerable amount of mud onto the latter. The manure is the most annoying of the two sources of dirt. "One thousand horses will, in every working day of eight hours, deposit about 500 gallons of urine and 10 tons of dung on the pavements. Inasmuch as over two thousand vehicles have been counted passing a given point on the street of a city during a single hour, the quantity of horse dung which may be deposited on a mile of city streets is evidently very large. The residue of this horse dung, that is, the undigested coatings of hay and oats, form a conspicuous ingredient of city dirt." (George A. Soper on Modern Methods of Street Cleaning).

In any project for increasing the efficiency and decreasing the cost of street cleaning, consideration should first be given to possible and practicable means and expedients for preventing the accumulation of dirt upon streets, thus reducing the quantity to be collected and disposed of by the street cleaning department. There is evidence that at least 30% by volume of the dirt comes from controllable sources.

Cans should be placed on street corners to receive waste paper, fruit skins, etc. (see Article 3). City ordinances should prohibit the placing of refuse and litter of all kinds upon the streets, and make it the duty of all police officers to arrest, without warrant, any person found violating them.

Street dirt is found upon the streets in two distinct physical forms, as coarse and often damp fragments, and in the form of mud in wet weather or dust in dry weather. The methods of street cleaning in common use remove principally the coarse fragments, leaving most of the mud or dust upon the surface of the street. It is this fine material which carries the germs of disease and is a menace to health besides being extremely annoying and discomforting. The amount of this dangerous dust left after regular cleaning is astonishing. The commissioners of one city found that from 0.1 to 4.8 cu.ft. of it remained on each 1000 sq.yds. of pavement after it had been swept. Measured by weight there is usually from 50 to 80 % more dust on block pavements than on asphalt.



ARTICLE 2.

DIFFERENT METHODS OF STREET CLEANING.

The following methods of street cleaning are in use in various parts of the United States and Europe. The first eight paragraphs describe the system of street cleaning as devised by the Merchants Association for San Francisco, California.

(1) BLOCK SYSTEM--There are 122 blockmen stationed throughout the principal wholesale and retail districts, each man being assigned to certain blocks, which he is responsible for keeping clean all day. All the dirt on these streets is picked up and deposited in special metal dirt boxes along the sidewalks, and removed by teams in daylight. A fixed price of 99 cts. per 1000 sq.yds. is paid for this work.

(2) MACHINE SWEEPING--Certain streets are swept at night by machines. The streets are first sprinkled, the dirt is then swept by the machine into the gutters, where it is gathered into piles by special men employed for this purpose, and afterward it is removed by teams before 7 A.M. 35 cts. per 1000 sq.yds. is paid for this work.

(3) HAND LABOR GANGS--All streets other than the above are cleaned by hand labor gangs. To each gang are assigned certain streets which it is to clean a fixed number of times each month. These gangs are to sweep the dirt into piles which are required to be removed by teams within two hours. This work costs 25 to 39 cts. per 1,000 sq.yds. in different districts each time the street is swept.

(4) SPECIAL CREWS-- Owing to the prevailing winds, it has been found that many streets have their gutters filled with dirt before the next sweeping is due, while the center of the street is practically clean. To increase the schedule and sweep the entire area of such streets would be a useless waste of money; and still the gutters require more frequent cleaning. This difficulty has been overcome by providing, in each district, for a "special crew" of three sweepers, a team, and a driver, whose duty it is to go over the streets, which are scheduled for cleaning, from once to four times per month and to clean the gutters only in the interval between the regular cleanings. These special crews are one of the best features of the street cleaning system, for besides this gutter cleaning they can be used to remove special accumulations, loose grouting and similar refuse in any part of the city, when not required on the sweeping. The special crews cost 33 1/4 cts. per hour for foreman and 65 cts. per hour for each team, wagon and driver.

(5) HOLIDAY AND SUNDAY CLEANING--On Sundays and certain holidays a crew of 14 sweepers and a foreman is provided to clean gutters and sidewalks from 6 A.M. to 10 A.M. on certain streets where people congregate. The cost of this is the same as the above.

(6) CROSS-WALK CLEANING--On rainy days, when the regular sweeping is suspended, a force of about 25 men is employed to clean cross-walks and sidewalks on the business thoroughfares most frequented by pedestrians. The cost is the same as for special crews.

(7) WASTE PAPER CLEANING--A horse cart and driver are pro-

vided during the windy season to cover those parts in the city where loose papers accumulate. These papers are picked up and removed at intervals during the day. The cost of the service is 50 cts. per hour for the outfit.

(8) STREET FLUSHING--The bituminous pavements in wet weather frequently become covered with a slippery coat of mud, which cannot be removed by brooms and cause many horses to fall. To overcome this a system of flushing is used. Two or three sprinkling carts with open flanges flush the streets thoroughly thus loosening the coating of mud. Following the carts is a gang of sweepers, who scrape the pavement with rubber squeegees. Bituminous rock and asphalt pavements are not slippery when thoroughly wet if the pavement itself is clean. This flushing has been found very effective in reducing slipperyness. The cost is \$1.00 per hour for each sprinkling cart, including water.

RESULTS OF THE SYSTEM--The system is good and complete. If followed strictly the streets will be well cleaned. It happens, however, that the contractors as a rule are likely to be careless and do no better work than they are obliged to do. Rigid inspection by the City inspector, accompanied by prompt rejection or fines for poor work is necessary to secure good results. It is, however, no easy matter to properly inspect the street cleaning since there are over 200 miles of paved streets in the city, and, besides the blockmen, there are twelve gangs of men working simultaneously in various portions of the city during the day time and the machine sweepers at night. Only two inspectors are employed to examine all this work and see that the specifications are complied with, which is evidently not enough

to properly do the work.

The principal defect has been the lack of sufficiently heavy sprinkling to prevent raising of dust. It is sometimes difficult to get drivers of sprinkling carts to use good judgment as to the quantity of water to be used on days of varying temperature and wind.

The machine work is well done. The rough pavements require heavy machines with brushes having long rattans. One of the parts of the machine work that is most often improperly performed is the cleaning up of the piles of dirt in the gutters. Drivers are apt to clean up these piles with a shovel alone and not use a broom to brush up the remnants of piles. This leaves the gutters in an unsightly condition and the contractor is liable to a fine of 50 cts. for each block or crossing upon which such remnants are left.

Much of the work of the hand labor gangs during the last two or three years has been bad. It should be much better than machine work, but, as a matter of fact, it has been worse. There is a limit to the degree to which a rough pavement can be cleaned by machine and nothing more can be expected, but there is no limit as to how well a basalt or cobble-stone pavement can be cleaned by hand labor. It has been an every day occurrence to see basalt and cobble paved streets which had simply had the refuse swept off the tops of the stones and showed no effort whatever to sweep the loose manure and refuse out of the joints. This is caused by the desire to cover as much ground as possible in a day, and because the foreman of the gang, who is also a sweeper, pays little attention to how his men sweep.

STREET CLEANING IN HAVANA, CUBA--The street cleaning there is done in a manner considered very credible. Cleaning is done by hand and the material is removed by carts to the dump where some of it is transferred by barges to the sea. The materials which are in an advanced stage of decay and such as would float are cremated; and harmless parts are used as a filling in the city. The force for the street cleaning includes 3 inspectors, 7 sub-inspectors, 51 foremen, 442 laborers and 33 water boys. The laborers are paid 84 cts. to \$1.00 per day. Cleaning of streets where traffic is heavy is done at night, a small force provided with push carts and cans being kept on the streets during the day time to keep them as clean as possible. The men are uniformed and well organized. They have given faithful service but it has been found difficult to make them interested in keeping their white uniforms clean. These uniforms are sold at \$3.33 per suit including shoes and hat, and give the force the distinctive appearance which has been found to work so well elsewhere.

The street sprinkling is an important work on account of the large amount of macadam which has to be kept damp in order to prevent dust. 13 sprinkling wagons, holding from 500 to 750 gallons each are in service, 9 of them being constructed so as to allow their use for distributing electrozone. Some of the streets are sprinkled with this disinfectant and in addition barrels of it are furnished for sprinkling in sewers, gutters, and wherever decomposed vegetable and animal matter is found. Sea water has been used to some extent and was found to keep the dust down decidedly better than fresh water.

ARTICLE 3.

RUBBISH CANS.

It is a growing practice for street cleaning departments to place barrels and baskets along the curb for the reception of newspapers and other large particles of solid refuse. These receptacles should bear a sign such as "Waste Paper Receptacle" or something similar. There is much to be recommended in this plan of using these receptacles, but it is important that they should be kept clean and never be allowed to become overfull. They should be placed in easily accessible places so that pedestrians can easily throw waste matter into them.

Experience and observation have shown that the problem which has caused most discussion in civic societies has been that relating to the most sanitary and efficient manner of gathering the rubbish off the streets, the newspapers, letters, and scraps that citizens, for want of better means of disposition, have been in the habit of throwing into the gutters. These off-throwings have been of small importance to the individual citizen, but are of a great matter when considered in relation to all the people of a city. Many years ago civic societies began to urge the use of cans on street corners for the gathering of this rubbish, with city wagons to visit them at frequent intervals to carry away what was deposited therein.

Many reasons present themselves to officers of cities why this rubbish should be cared for. Among them are the appearance of the streets, comfort during windy days, and safety of build-

ings. A city with littered streets does not appeal to visitors. When the day is windy flying paper makes travel uncomfortable and often dangerous. Piles of refuse in alleys and vacant lots are a menace to property as a carelessly disposed cigar may set the whole on fire.

To meet this emergency the sanitary rubbish can has been made and patented. As a result of its trial, it is now the official can of Denver, Col., where it is used on all public streets to the exclusion of any other manner of gathering the rubbish. It has been found to be sanitary, effective, cleanly, and to allow a sure and rapid gathering of all rubbish of the city. Within a short time after they were placed on the corners to replace the old battered, unsteady, unsanitary and awkward contrivances, it was noticed that citizens no longer threw away paper wrappers, envelopes, notes, torn scraps of paper, banana and orange peelings, etc. Instead they held them in their hands until the next can was reached.

The records of the Street Cleaning Department of Denver show that the first attempt at having the rubbish thrown into cans was successful, and the amount of it was trebled. What was at first a convenience to the people, to the city and to the owner of property became a necessity. It improved appearances, added to comfort and perhaps is destined to make insurance companies look upon risks in a more lenient manner.

The can itself is a very simple affair. It stands 36 in. high with sides of 19 in. each. The height makes it easy for pedestrians to drop in their waste as they pass. Adjustable feet are under each corner, so the can, which is designed to be

attached to a street post, may be permitted to adjust itself to the pitch of that post or to the slant of the walk. Within the can is a large sack fastened to hooks within the top, but swinging clear of the walk. This sack is hung on hooks directly under the removable top so arranged that when the top is down and locked the sack cannot be removed. The movable top is really a hopper through which the waste passes to the receptacle sack within. The sack can be removed only when the hopper top is unlocked and put to one side. This is to prevent any but those authorized from removing the sacks or any considerable part of the contents. Of course, as the hopper is kept open to facilitate the depositing of rubbish it is within the possibilities that the spurious may inspect its contents, or part of them. The sanitary idea is carried out by having perforations in the bottom of the sack to permit the escape of moisture and this, together with the arrangement for the free circulation of air through the can, which has an open bottom, keeps the contents as dry as possible.

An objection was raised that the waste being very inflammable, danger might be incurred because of the throwing of cigars and cigarette stubs in among the rubbish. This has happened but once in Denver where the cans have been on trial, and even the presence of the can was an added safety for it kept the fire within bounds, so that no damage resulted to anything but the contents of the can and sack.

A great point in favor of the sanitary cans lies in the removal of its contents. The top is taken off, the sack lifted from the hooks supporting it, the drawstring at the top pulled

closing the mouth, and the whole is thrown upon the wagon which is to bear the rubbish away, and replaced by an empty sack. There is no possibility that the contents may be blown about the streets thus undoing the work of the can. The can permits everything to be done in so cleanly a manner that the arrival of the dust wagon is not a signal for the storekeepers to close their doors in fear of a gust of wind carrying dirt to the interior.

ARTICLE 4.

STREET CLEANING IMPLEMENTS AND MACHINES.

SHOVELS--There are many styles of shovels but only one or two kinds are adapted to street cleaning work. The scoop shovel is the best kind as it is light and has a greater capacity than the other kinds. After the street dirt has been swept into piles along the gutters, scoop shovels are used to throw the sweepings into carts or wagons. The price of these shovels ranges from 60 cts. to \$1.25.

ASPHALT SCRAPER--Fig. 1 gives a good idea of this scraper.

When used it is pushed along the pavement and cleans a swath as wide as the blade. It cannot be used on brick or rough pavement as it

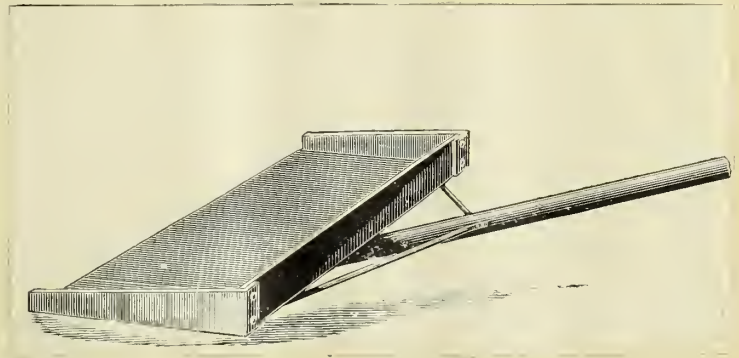


Fig. 1

would be impossible to push the scraper along

since it would catch in the cracks or any irregularities of the surface. In Peoria, Ill., an asphalt scraper with a blade about 8 ft. long and 8 in. wide is used and seems to give good results.

GUTTER HOE--

Fig. 2 shows an implement manufactured by

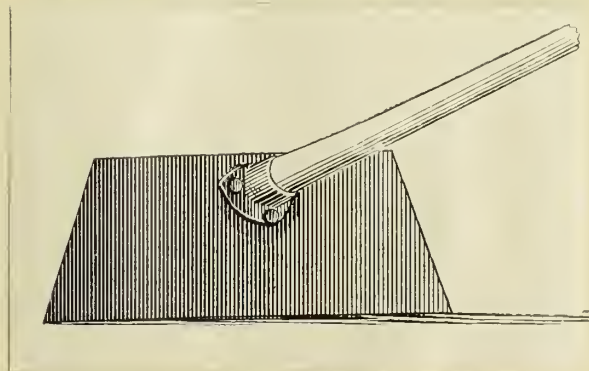


Fig. 2

Hvass & Co., New York. It is used mainly for cleaning out gutters and scraping together windrows of the street sweeper. The handle is detachable and can always be re-used.

HAND BROOMS--There are many varieties of street hand brooms in use, but the following are the most common.

Fig. 3 shows a broom 6 inches long, made of split bamboo with rattan center.

The fibres flare out considerably on the ends thus enabling one to sweep close to the curbing. The elasticity of the fibres and the light weight of these brooms make

them especially desirable for street sweeping. These brooms cost from \$55. to \$65. per gross, or 38 to 45 cts. apiece depending on the number of rows of fibres.

Fig. 4 shows an extra stiff broom with African base fibres. The price is \$90. to \$100. per gross, or 63 to 70 cts. apiece.

Fig. 5 shows a round steel wire scrubbing broom. The price is \$8.00 to \$12.00 per doz. depending on the size, or 66 cts. to \$1.00 apiece.

Extra handles for brooms cost from \$10. to \$15. per gross or 7 to 10 1/2 cts. apiece.



Fig. 3



Fig. 4



Fig. 5

Figs. 6 and 7 show two kinds of switch and track brooms. These are useful on streets having electric car lines. The upper ends of the brooms are provided with chisels (see Fig. 8) which can be used in cleaning the dirt from between the rail and guard rail. The price of the broom shown in Fig. 6 is \$8.65 per doz. or 72 cts. apiece, and the price of the one shown in Fig. 8 is from \$4.30 to \$6.30, or 37 to 52 cts. apiece.



Fig. 6



Fig. 7



Fig. 8

CANS AND CAN CARRIERS-- These are useful where the patrol and block system (see Art. 2) are used. Fig. 9 shows the Twentieth Century can and can carrier manufactured by Wirt & Knox. The main frame, which is of steel tubing passes outside the carrying wheels, serving as a protection from danger of collision or other accident on the streets, and at the same time affording a double bearing for the wheels. This equalizes the pressure on the axle and greatly increases the carrying capacity. The bed or platform on which the can rests is low down, permitting of easy removal of the filled can. A slight downward pressure on the handle serves to elevate the carrier for the purpose of crossing a curb or other obstruction. The main wheels are 50 inches high with malleable iron hubs. These

carriers are light, strong and durable. The carrier weighs 75 lbs. and the empty can 32 lbs., making a total of 107 lbs. The price of the carrier with steel wheels is \$12.50, and with wooden wheels is \$15.00, and the price of the can is \$4.00.

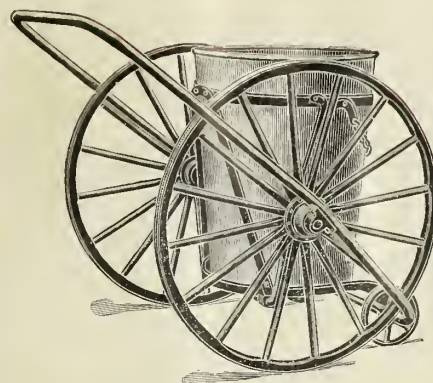


Fig. 9

Fig. 10 shows a can carrying wagon manufactured by Hvass & Co., New York, N.Y. These are used for the collec-

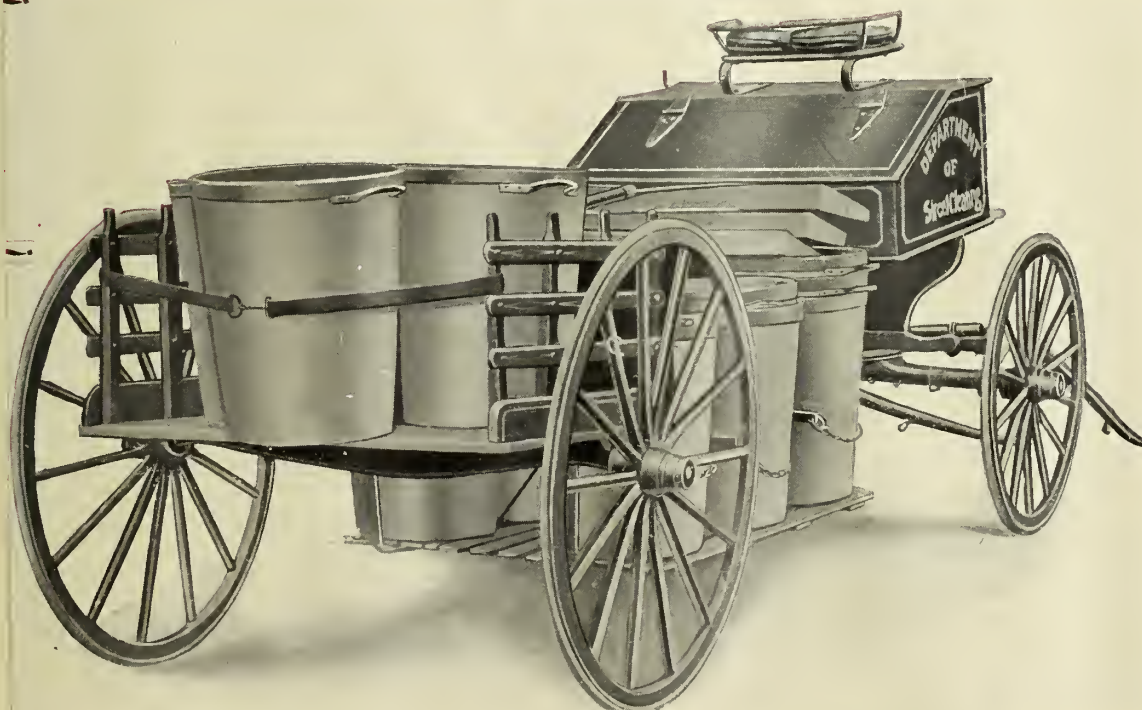


Fig. 10

tion of the cans and carrying them to the place of disposal. The wagon shown holds ten filled cans and is easily drawn by

one horse.

CARTS AND WAGONS--Wagons and carts are used to haul away the refuse. They should be especially adapted to their work, but it is common to see unsuitable vehicles employed. The wagons should be large, low-bodied, light, tight, covered and easily dumped. In foreign countries the tendency is to use metal covered carts, but in this country nearly all the carts are of the open variety. One objection to the open cart or wagon is that if they are filled up, as is usually the case, the dirt will be spilled off a little at a time as the carts are taken to be dumped, and also a strong wind will blow the dust and any papers from the tops of the loads.

HAND SWEEPER--Fig. 11 shows a sweeper which works on the same principle as the larger horse drawn machines. It is used



Fig. 11

in many places for the block system (see Art. 2), and also for cleaning docks, parks, private grounds, skating rinks and lodge halls. The broom used in this machine is 3 ft. long and will last for the actual period of four months used daily. In going to and from work it is necessary to raise the broom so that it will not sweep. This is done by throwing the handle over to the opposite side of the machine. The saving of labor and brooms will more than pay for the cost of the machines in a short time.

Fig. 12 shows a two horse steel sweeper. Clean sweeping depends considerably on the control and accurate working of the broom. One of the important features of this machine is the attachment of the broom to the sweeper, being arranged in such

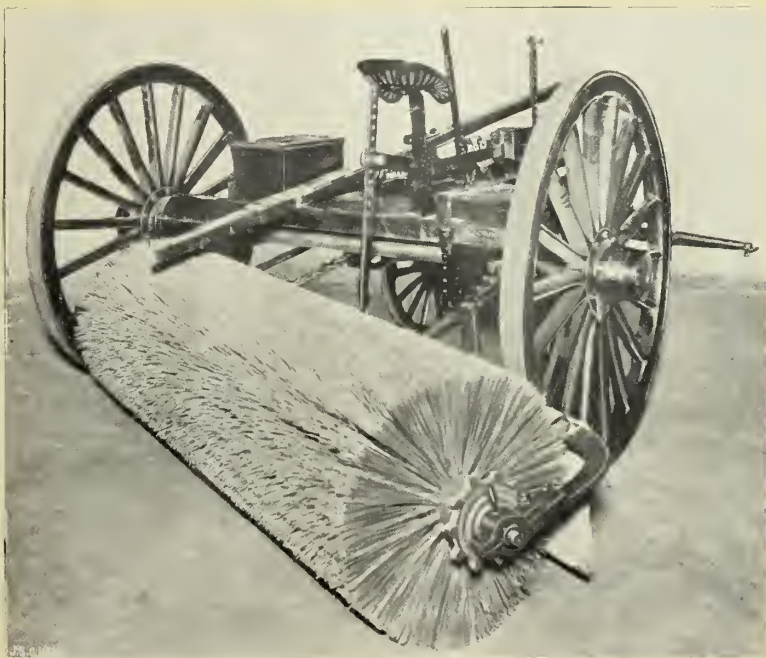


Fig. 12

a manner that the broom follows any inequalities of the pavement giving the best possible results on all kinds of pavements from the smooth asphalt to the rough cobblestone. The adjusting lever of the machine is fitted up with a balance weight arranged

to give the amount of pressure required, which can be maintained until the broom is worn out. This pressure can be changed instantly to suit all conditions and produce a clean swept surface. The main frame is made of steel, braced with angle iron and riveted so there are no bolts to get loose and no wood frame to warp or shrink. All the other wrought iron pieces and necessary parts are fastened by jam nut bolts producing great stability. The power is transmitted from the main axle, of 2 7/16 in. steel, to a chain. The running gear consists of two rear wheels 60 in. in diameter and two front wheels 30 in. in diameter. The broom is 28 in. in diameter, 8 ft. 4 in. long and sweeps a swath about 7 ft. 4 in. wide as the broom is hung at an angle with the axis of the machine. It is lowered or raised by adjustable weight lever and put in or out of motion by lever operating clutch. The sweeper is protected from the swept mud and dirt by a sheet iron broom guard. This machine is manufactured by P.F.Campbell and costs \$300.

The Austin Mfg. Co. make a machine with a broom 30 in. in diameter and 9 ft. long hung at an angle so that it sweeps a path 7 ft. wide. The machine weighs 2450 pounds. Its sweeping capacity is 90,000 sq.ft., or 3340 sq. yds., of street surface per hour, which equals upward of five miles of thirty-five foot wide streets from curb to curb in ten hours' work.

A SUCTION STREET SWEEPER--A street sweeper which sweeps and takes up the dirt by suction was used in Hartford, Conn., with good results in dry weather. This machine, which was first used there in 1901, was quite crude and needed constant repairs, but it swept the pavements satisfactorily and without annoyance

to people at the rate of 23.2 cts. per 1,000 sq.yds. The cost of sweeping with a rotary broom sweeper which was used in connection with a water sprinkler, cost 30.4 cts. per 1,000 sq.yds. and hand sweeping cost 50.3 cts.

AUTOMOBILE STREET SWEEPER--These were introduced in Paris about two years ago and have been in use during that time in competition with the ordinary horse-drawn vehicles, with very satisfactory results. The machines are gasoline driven, two cylinder 15 H.P. automobiles, with a body 14 1/2 feet long and 7 feet wide. The brush is hung about midway between the forward and back axles, at an angle of 52° with the longitudinal axis of the machine. This brush is 7 feet long sweeping a path about 6 feet wide. Attached to the chassis of the automobile is a large cylindrical tank holding about 1,000 gallons of water so that the sweeper may be used as a street sprinkler either simultaneously with the sweeping operation or by itself.

Extensive tests as to the relative efficiency and cost of the horse drawn and automobile sweepers have been carried on during the time that the latter have been in use. With the automobile machine the speed reached as high as 10 miles per hour, but the average was reduced to 5.4 miles by stopping and slowing down on account of traffic on the streets. The width of the single strip swept was about 6 feet, the surface covered each day reaching approximately 120,000 sq.yds. The horse-drawn sweeper was able to sweep daily a length of 13 miles over a strip 5 1/2 feet wide, making a total surface of about 42,000 sq.yds.

Thus it is seen that the automobile did about three times

as much as the horse-drawn sweeper. The reason for this great difference is due to the fact that the automobile travels faster than the horse-drawn machine. In this country the horse-drawn machine sweeps a path 7 to 7-1/2 feet wide as compared with the 5-1/2 feet in Paris, thus making the difference in the area swept less than three times as much for the automobile as for the horse-drawn machines. Also where one machine can do the work of three there is a saving in the wages of the men.

The average daily costs, including labor, depreciation, lubrication, etc., were for the automobile \$8.11 and for the horse-drawn sweepers \$7.76, but the former did three times the work of the latter.

Considerable attention was paid to the brushes used in the automobile machine. Attempts were made to substitute steel wires for ordinary rattan bristles, but difficulty was found in getting a steel wire of sufficient elasticity to serve the purpose. Most of the steel wire acquired a permanent bend after a few weeks' use. In addition they soon rusted and wore out under the combined effect of weather and friction.

A MOTOR DRIVEN STREET CLEANING MACHINE--A new type of machine (see Fig. 13) has lately been tested on a portion of 4th Ave., New York City, under the direction of the Street Cleaning Department. The manufacture and operation of the machine are controlled by the Emerson Contracting Co., New York City. The machines are patented and cannot be bought but may be leased from the company under a contract which provides for payment on the basis of the actual area of street surface cleaned.

The essential parts of the machine consist of a motor driven truck, a rotary broom and a belt conveying device. The general arrangement of the parts is shown in Fig. 13, which shows a view of the rear of this machine. The broom and the conveyor are contained in the overhanging portion of the machine and are entirely enclosed in a metal casing so that when the apparatus is in operation, no nuisance from dust is caused. The broom is 6-1/2 feet long, and is made of steel. It is rotated through a system of chains and gears from the 40 H.P. gasoline engine which supplies the power both for propelling the machine and operating the broom and conveyor. Under the body of the machine



Fig. 13

is a long rake which may be lowered onto the street surface to facilitate the work of the broom by breaking up and loosening the dirt which sticks to the pavement. The rake also intercepts large size matter which might injure or interfere with the work-

ing of the broom and conveyor.

Two men are required to run this machine, a driver on the front end and an attendant on the rear who controls the sweeping operations. While sweeping is in progress, the broom carriage travels along the pavement on a pair of small rollers and the sweepings are conveyed by the belt conveyor, to a large dust and dirt compartment on the rear end of the machine. When the machine has collected a load of dirt and starts on its way to the dump, the broom is lifted clear of the street surface to allow of greater speed.

Arrangements are made for sprinkling the streets while sweeping, a large tank being placed on the top of the motor truck above the dust collecting compartment. From this water may be supplied under pressure to a row of jets placed in front of the broom. The admission of water to these jets is controlled by the attendant from his seat at the rear of the machine. The streets may be cleaned with or without the use of water. When cleaning with water only about 40 gallons per 1,000 sq.yds of street surface are required.

The machines are built in different sizes and the dust collecting compartments are generally designed to contain when full half a day's sweeping. The compartment is emptied by gravity through dumping doors in its bottom.

Among the advantages which the designers of these machines claim for them are:

- (1) The streets can be thoroughly and rapidly cleaned without the use of water, and without causing dust, permitting cleaning during several months of the year when water cannot be

used as it would freeze on the pavements.

(2) Streets can be cleaned with water under pressure.

(3) All sweepings, wet or dry, are taken up into the machine and carried by it to the dump so that no debris is washed into the gutters, catch basins, or sewers.

(4) The machines are adapted to all of the various types of pavements.

COST OF STREET SWEEPING BY MACHINES--"In January, 1900, Mr. Andrew Rosewater, City Engineer of Omaha, Neb., collected data of the cost of street sweeping in 35 of the largest cities for the year 1898. It is unfortunate, however, that the data were not secured to show how many times the average street was swept in each city, for then we could have determined the cost per 1,000 sq.yds. swept once.

"Excluding New York, Chicago, Philadelphia and Pittsburg, because the cost in those cities is extremely high, the 31 remaining cities have 3,670 miles of paved streets with an area of 71,439,091 sq.yds. Hence the average width of pavement is 33-1/4 ft. which is equivalent to 3.7 sq.yds per lineal foot of street, or 19,500 sq.yds per mile. The estimated cost of cleaning these 31 cities was 3.23 cts. per sq.yds. of pavement for the year or \$32.30 per 1,000 sq.yds.

"A common cost of sweeping is about 20 cts. per 1,000 sq. yds. swept once. Hence if a street is swept 3 times per week, or 156 times per year, the cost is 3.12 cts. per sq.yd. or \$31.20 per 1,000 sq.yds. per year" (Gillette's Handbook of Cost Data).

GUTTER SWEEPER-- The principle of the pinion gear of this

machine (see Fig. 14) is the same as on other machines, except



Fig. 14

that the broom revolves on a vertical axis instead of a horizontal axis. It can be set at any angle that may be required to thoroughly clean the accumulation of dirt from the gutter. The broom sweeps a path a foot wide and is so manipulated by a spring that it works well into the corners. The ordinary sweeper sweeps the dirt in piles along the gutter and the men remove them with shovels only in the majority of cases and make no pretense of sweeping up the remnants of the piles. It is, therefore evident that the use of the gutter sweeper is advisable for the above reason,

PAVEMENT SCRAPER--The Austin Mfg. Co. have constructed a scraper that can be used as a reversible grader or for scraping

macadam or paved streets where the debris is too heavy to be removed by a street sweeper, and is especially adapted for spring work to remove accumulations of the winter. It is a labor saving devise, doing the work much better and more quickly than can be accomplished by hand and will effectively scrape 75,000 sq. yds. of pavement per hour, the horses moving at a moderate rate of speed. It is constructed principally of steel, great strength being secured by special rolled shapes. The scraping attachment is composed of twenty-seven independent chilled shoes about 4 in. wide, which are held close to the pavement and in exact position by heavy springs which act independently of each shoe. The difficulty of cleaning rough pavement is thereby removed. Should one of the shoes come in contact with an obstruction the springs permit it to pass over, thus saving the pavement and not straining the machine. The shoes drop themselves into any depression in an uneven pavement and do their work of cleaning thoroughly.

The pavement scraping attachment can be removed and replaced by a grader blade. The machine is then ready for the heaviest and hardest kind of road grading.

FLUSHING MACHINES--All of these machines, excepting the Studebaker and Squeegee, which are described below, have the same general principle of operation. They consist of a tank of heavy-boiler steel construction, furnished with an inner chamber for the storage of compressed air. The water is introduced at the bottom at the rear of the machine and as the tank fills the air is compressed in the air chamber. When in operation the reverse of the operation gives the delivery of water under pres-

sure furnished by the compressed air, and at a pressure dependent upon that obtained from the hydrant pressure. The water is delivered to the street at an angle which permits of its most effective use in cleaning. The angle is adapted to the different kinds of pavement by adjustment of the nozzle.

The Connelly Flusher--This machine has a capacity of 700 gallons, but when charged for use it contains less than this quantity, owing to the air which is in the tank, used to force the water out under pressure. There is a separate water and air chamber running through the water tank in the center of the same.

The Sanitary Automatic Flusher--These machines (see Fig. 15) are built of one size with a capacity of 600 gallons. The air chamber and the water compartment of the tank are supplied with manhole, permitting of easy access to the interior of either. The tank is charged automatically with air direct from the hydrant while filling with water, doing away



Fig. 15

entirely with the separate compressed air charging device, as in the Studebaker machine. In using this machine, and also in the one above described, the machine should first be driven to the center of the street, working the dirt toward the curbing by going down one side and back the other.

The Studebaker Flusher--This machine has a tank like that of the ordinary flusher, but this tank is filled at the top

without any attempt at air compression. Water is forced into the distributing pipe by a centrifugal pump having a direct connection with a gasoline engine located in the rear of the machine. A uniform pressure of anywhere from 5 to 32 lbs. can thus be maintained until the last gallon of water is taken from the tank. In other types when the tank empties the air expands to fill the place of the water used up, and uniform pressure cannot be maintained.

The Kindling Squeegee--This machine (see Fig. 16) is a German invention which has been for some years in successful operation in leading German cities. Year by year it has become more popular, until now it is in general use in the chief municipalities of the Continent, and is universally recognized as the most thorough and economical of all machines for the cleaning of smooth pavements--asphalt, bitulithic, tar macadam, wood block



Fig.16

and brick.

The tank feeds four sprinklers between the front and rear wheels, all operated with valves by the driver on his seat. One or more of these sprinklers can be used at the same time, according to the amount of water required to remove the accumulation on the pavement, or the water supply can be entirely shut off where the pavement is already wet enough, as after a heavy rain. Geared to the left wheel is the cleaning roller which consists of a core 10 in. in diameter into which the rubber strips are fastened. There are twenty-four of these strips, each $3/8$ in. thick projecting $4-1/2$ in. from the core so that the size of the roller is about 19 in. The strips are placed spirally and this combined with the stiffness of the rubber keeps them from turning down easily or flopping.

To the right of the driver's seat is a large lever, by which the cleaning roller can be raised or lowered. Should the roller be too high, the counterweight can be set back a few inches; if too low, it can be set forward. The rubber blades should merely touch the pavement and should not be bent very much, as the latter position not only causes the rubber to break and wear faster, but has a tendency to smear the accumulation instead of removing it. The rubber blades should wear off at a blunt angle and not at a sharp angle.

The advantages claimed for this machine are:

(1) The machine will clean 40,000 to 75,000 sq.yds. of pavement a day, according to the condition of the street.

(2) The consumption of water is very small for the results obtained as there is no waste, practically every drop being caught up by the squeegee as it washes the pavement.

(3) Actual tests have shown that the rubbers in the squeegee last from 300 to 400 working days, thus making the cost of replacing the rubber about half the yearly expense of renewing brooms.

(4) All dirt, slime and grease is removed from the pavement.

(5) Pavements are dry a few minutes after the squeegee has passed and there is no danger of slipping of horse or pedestrian, or skidding of automobile.

(6) As the water is sprinkled lightly over the surface, there are none of the injurious effects of flushing under heavy pressure as when done by hose or flushing machine.

(7) The squeegee leaves the dirt in windrows along the gutters where it is gathered up and taken away in carts. Flushing by machines or hose washes the dirt into the sewers, from which it must be taken by the sewerage department to prevent clogging.

The squeegee weighs 3,350 pounds without the water and costs \$1250.

Hose Flushing--The hose is made of rubber, is usually 2-1/2 in. in diameter and 50 to 200 ft. in length. It has a nozzle generally circular in cross-section and about 3/4 in. in diameter. It is often provided with a deflector by which the shape and force of the stream can be regulated. In the city of London the discharge at the nozzle averages 80-1/2 imperial gallons per minute. Much skill is used in handling the hose and the man at the nozzle receives more pay than the other workmen.

The stream is always directed well ahead and straight to-

ward the material to be removed, the idea being to use the water to sweep the dirt away, rather than to lubricate the dirt for sweeping. The lubrication is always very thorough and is done by sprinkling carts in advance. This preliminary wetting is in reality the secret of the art of successful flushing.

The flushing in this country is generally done with standard fire hose and nozzle, the full hydrant pressure, from 75 to 100 lbs. per sq.in. being applied. This is wasteful of water and the force of the jet is unnecessarily great. It is believed that a smaller nozzle of special shape, and the reduction of the pressure to not more than 30 lbs. at the nozzle would give equally efficient and nearly as rapid results, while cutting down the quantity of water 40%, and decreasing the cost 21%. The Street Cleaning Commission of New York considers machine flushing no more effective than hose flushing, but that the former is much more expensive and less preferable.

In the City of New York tests were made of several varieties of flushing and street washing machines. A description of these tests were given in Engineering News, April 14th, 1910, and the following table is taken from this article.

"Arrangements were made with the owners of various types of machines by which they furnished a certain number of machines for an approximate test of 100 days at a per diem rate. Under this agreement the machines tested were: 10 American, 5 Ratigan, 10 Connelly, 13 Squeegee, 10 Sanitary, and 1 Studebaker."

It will be seen from the following table that the Squeegee machine averaged the greatest number of sq.yds. cleaned and the amount of water used was less than half that of the least of the

others. As a price of 13-1/2 cts. per 1,000 gallons has been placed on water, the saving on water by using the Squeegee as compared to the amount used by the next lowest consumer is $(354-148) \times .0135 = 2.78$ cts. per 1,000 sq.yds. It will be noticed, however, that the Squeegee machine was used only on asphalt.

Summary of Data Obtained from New York Street Flushing

Machine Tests, 1909.

Type of Machine	Percentage of Various Pavements			Sq.Yds Cleaned		Gallong of Water used Av. per
	As- phalt	Gran- ite	Wood	Total	per day	1000 sq.yd
American	74	16	10	14,279,105	18,353	542
Ratigan	71	27	2	4,831,603	14,169	613
Connelly	79	16	5	20,424,690	30,469	354
Squeegee	100	--	--	7,484,766	51,977	148
Sanitary	85	13	2	13,651,179	22,828	477
Studebaker	43	57	--	142,992	34,658	528

ARTICLE 5

A COMPARISON OF THE DIFFERENT METHODS OF HAND AND MACHINE CLEANING

A decided difference exists in different cities in the methods adopted to accomplish the same results in street cleaning. In one city the work is chiefly done by hand labor, while in another much use is made of machines. The explanation appears to be that, until recently, little or no attempt has been made to standardize the methods. Each city in America, as in Europe, has developed its own ways of cleaning streets without much reference to the experience of others, and, once used to a certain system, a radical change has been slow. It is not that the streets or traffic differ so materially in different cities but that the customary ways of cleaning the streets have become somewhat fixed so that these differences continue to exist.

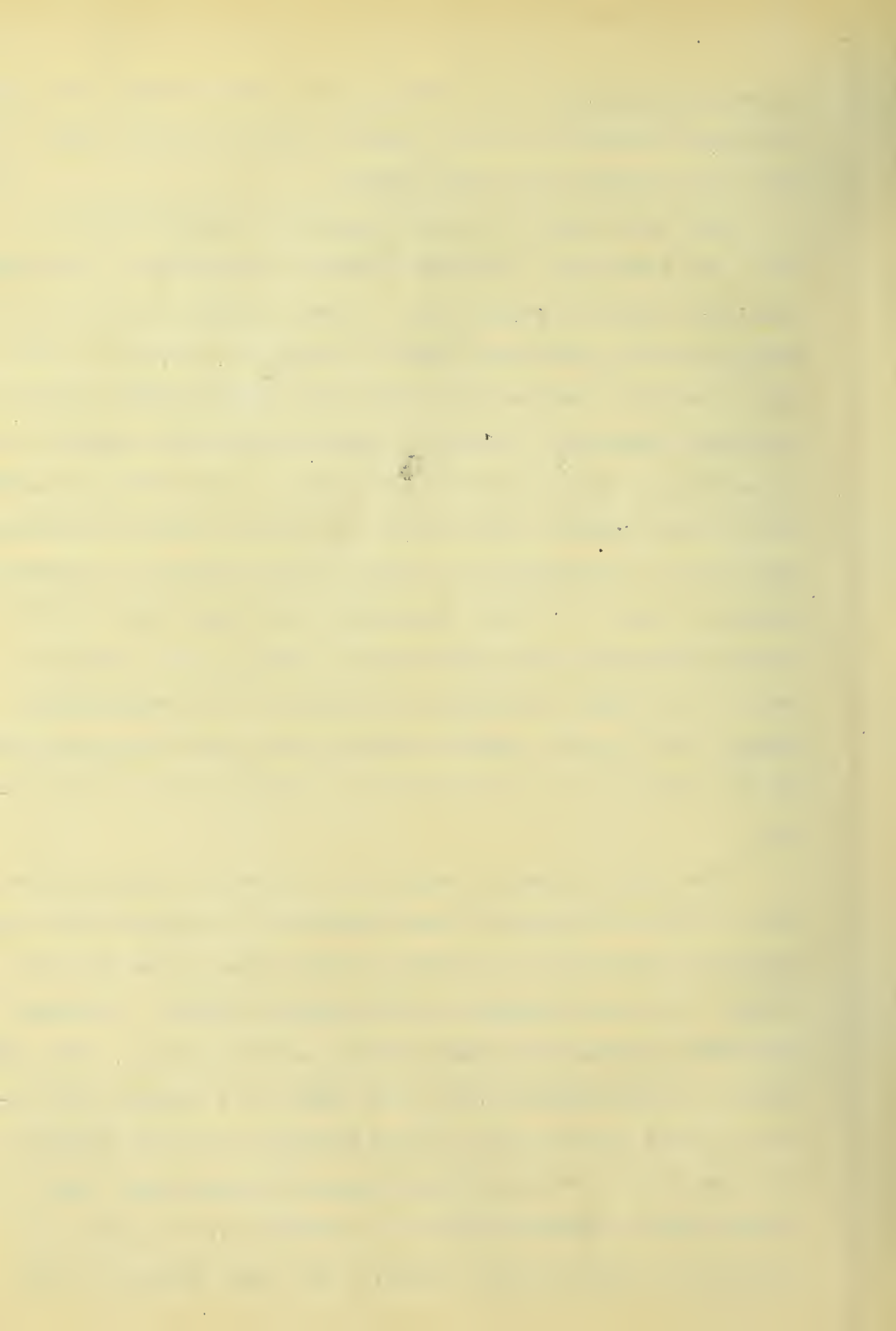
Although the hand workers are provided with shovels, iron scrapers, brooms and, in some cases, hand-propelled sweeping machines, they do not and cannot remove all the dust and mud which it is desirable to remove from a city street. Nor can hand-workers compete with horse-drawn or motor-propelled rotary brooms in removing large amounts of dirt from pavements. Hand-work is best on pavements which are in poor repair.

The attempts made to use sweeping machines are often decidedly crude. The brooms are not always preceded, but are sometimes actually followed, by sprinkling carts. Too often no

sprinkling accompanies the sweeping, the result being that dirt is raised through the air in clouds of dust to settle again upon the pavement and in the houses.

The best method of street cleaning is the one which removes the fine dust. Combined flushing and washing is the only practical method of doing this. To most persons to flush is to carry something which can float or be easily removed by a current of water. The dust and dirt upon a street often cannot be dislodged unless wet, except by considerable water pressure or by scrubbing. This large amount of water injures the pavements. For the best results, the dirt to be removed from the pavement must first be thoroughly lubricated before the hose or flushing machine is used. In this lubrication lies the secret of efficient cleansing by the water method. The use of a stream of water is of value, not alone on account of its transporting powers, but from the sweeping action which can be brought about by the stream as it is directed by a skillful hand at the nozzle.

" The Street Cleaning Commission of New York compared the cost of street cleaning by hand-sweeping, by sweeping with horse propelled brooms and by the use of water from a hose and concluded that hand sweeping was the cheapest method. In these estimates allowance was made for the cost of repairs, interest charges on the apparatus, etc. The wages of a laborer were taken at \$2.19 per day, the cost of keeping a horse at \$1.35 a day, the cost of water at \$90.00 per million gallons. One sweeper was considered capable of cleaning 8,000 sq.yds. of pavement in a day of eight hours, a two horse machine 70,000



sq.yds. In flushing with water from a hose it was assumed that 5000 sq.yds. could be cleaned with 1.88 gallons per sq.yd. Two laborers of the rank of sweeper were thought to be enough to operate the hose. On this basis hand-sweeping was estimated to cost 28 cts., machine sweeping 31 cts., hose flushing 32 cts. per ¹⁰⁰sq.yd., and flushing by a patented amchine 72 cts. per 100 yds." (George A. Soper's Modern Methods of Street Cleaning)

Cleaning by means of the squeegee is perhaps the best method for removing the fine dirt, slime grease, etc. This machine does not wash the dirt into the sewers as is the case with hose and flushing machines. As the water is sprinkled over the surface, there are none of the injurious effects or flushing under heavy pressure.

On the next page is given a table showing the methods employed in all cities over 3,000 population. It will be seen that 92% of these cities cleaned their streets by day labor alone, 6.3 % by contract alone, and 1.7% by both plans. 69.5% cleaned by hand, 6.2% cleaned by machine and 24.3% by both methods.

COST OF CLEANING VARIOUS KINDS OF PAVEMENT.-- In order to obtain the best results from any method of street cleaning, it is necessary that the pavement should be good and kept in good repair. It makes less difference what kind of pavement is employed than what condition the pavement is in. Considering the three conditions of good, fair and bad repair, the Department of Street Cleaning of New York believes that the cost of keeping clean a pavement in fair repair is 20% and one in bad repair 40% greater than one in good repair.

STREET CLEANING STATISTICS FOR U.S.

Population	No. of Places		Day Labor			Both Day Labor and Con- tract	Contract		
	Total	Report- ing	Hand	Ma- chine	Both		Hand	Ma- chine	Both
3,000 to 4,000	384	311	248	9	22(8)	4	16	3	(1)
4,000 to 5,000	236	205	162	2	23(5)	1	6	4	2
5,000 to 10,000	465	435	299	11	76(8)	9	13	10	7(2)
10,000 to 20,000	226	215	113	10	74(2)	4	5	6	1
20,000 to 30,000	78	76	40	6	29	-	--	1	-
30,000 to 40,000	43	41	13	3	25	-	--	-	-
40,000 to 50,000	14	14	5	1	8	-	--	-	-
More than 50,000	78	77	7	10	43(1)	7	2	2	5
Total	1524	1374	887	52	300(24)	25	42	26	15(3)

Note--Numbers in parenthesis indicate the report "Day Labor" only or "Contract" only.

Asphalt is regarded with the greatest favor where there is much light traffic, as it is the easiest to clean. On account of its smoothness, however, it requires the largest amount of cleaning to keep it looking well. The asphalt scraper and squeegee are used to better advantage on this kind of pavement than on any other, although all of the other methods can be used as well or better on this pavement. The cost of sweeping asphalt in Washington, D.C. in 1901 was 18.6 cts. per 1000 sq.yds for each sweeping.

Wood pavement, composed of soft wood is much employed in England, and to some extent in this country, but wood is not yet so popular as brick or asphalt in this country. When new the wood block pavement is easy to clean but when old and full of depressions it is difficult to clean, besides interfering greatly with traffic.

Brick pavement is probably the commonest in this country while in Europe stone, including granite blocks, is more often used. Next to asphalt, brick is probably the easiest to clean on account of its smoothness. If the joints are filled with sand, flushing should not be done. Stone pavements are difficult to clean on account of their roughness. It is next to impossible to flush them.

In New York they have found that the average cost of cleaning equally well the variously kinds of pavement under similar conditions of repair is as follows: sheet asphalt 100, wood block (new) 105, asphalt block 115, brick 120, wood block (old) 125, Medina stone block 130, granite block 140, Belgian block 150, and cobblestone 300. These figures suggest that

the relative cost of cleaning is an element of no little importance in selecting the kind of pavement.

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ARTICLE 6

SNOW REMOVAL.

The removal of snow is universally considered to be an unsatisfactory problem to deal with, although it offers much greater difficulties in some cities than in others. In Berlin and North German Cities, generally, the winters are severe and occassionally snow storms occur which compare with the worst that are experienced in New York.

Sometimes the snow is a foot or more deep at one time and it is almost impossible for horses and wagons to move along. In the large cities on the principal business streets where traffic is very great at all times of the year it is necessary to clean off all snowfalls over half a foot deep in order that traffic may not become so restricted as to seriously cripple business.

There are various methods of snow removal in general use. One or more of these is in use in the following cities:

NEW YORK-- Before 1896 snow was removed by the department force aided by laborers temporarily employed for the purpose. Snow is removed from the streets by contracts drawn up and let, after public bidding, by the Street Cleaning Department. The regular force is quite incapable of dealing with the problem and at the same time keeping up with their regular work. The contracts are entered into each year just before winter sets in. The contractors collect the snow from the pavements and carry it off for so much a cubic yard. The sum spent for this work in 1907 was \$2,470,950.47 and the quantity removed was 13,905,181

ubic yards.

When snow begins to fall the sweepers of the department leave their ordinary work and clear the crosswalks, remove snow from and about fire hydrants, and free the gutters so that in event of thaw the water from the melting snow can run off into the sewers. It not uncommonly happens that the temperature immediately after a snow-storm is such that the snow melts during the day and freezes at night, so that if care is not taken to keep the drainage of the streets clear, ice may accumulate.

The contracts entered into by the city for the removal of snow usually specify that work shall begin when two and one-half inches of snow have fallen upon the pavements, the depth to be determined by a special officer of the Street Cleaning Department. When the word is given by this officer, the contractor puts his men upon the streets and works where the department directs. The force of labor employed often numbers many thousands and is recruited from whatever source may be available at the moment. The horses and carts are obtained by the contractor wherever he is able to get them. They are of every sort, kind and description. The workmen shovel the snow into piles and then load it into the carts. The carts carry the snow to the harbor and empty it into the water from the bulkheads.

Two systems have been devised for estimating the quantities of snow. By one of these systems the quantity of snow removed has been computed by multiplying the area cleaned by the depth of the snowfall. The chief advantage of this plan of estimation is that it saves a large amount of supervision which the Street Cleaning Department must exercise over the accounts.

It was devised to prevent fraud and to economize in the number of city inspectors required. Its defects include the possibility of great shrinkage due to rain and sun. This system was put in use after the winter of 1902-03. The other system of reckoning is by actual count of the carts and an estimation of the capacity of each. This plan has certain advantages but owing to the very large amount of attention required by the city to prevent errors, the regular work of collecting refuse from the houses has to be abandoned at times in order to provide enough inspectors.

Up to the present time no entirely satisfactory method has been devised for cleaning the snow from the streets or determining a just price for removing it. Snow melting machines have been tried without success. Salt is sprinkled on some of the streets by the railway companies but is objected to because of its chilling effect on the feet. The snow has been shoveled into sewers to some extent, but this is not approved of by the authorities in charge of the sewers. Snow plows are used only by the street railway companies. The objection to the use of plows on the streets is they do not remove the snow but merely push it to one side..

The cost of dealing with the snow is very large. A winter like that of 1907-08 may occur with practically no snow except such as is almost immediately melted by weather conditions. The prices range from 15 to 25 cts. a cubic yard, and a single storm may cost the city through the Street Cleaning Department \$500,000.

DETROIT, MICH.--Snow removal was greatly facilitated in

this city in 1901 by dumping snow, slush and even ice through large manholes into a 9 foot sewer 25 to 37 feet below the surface of the street, there to be melted and carried to the river.

BERLIN, GERMANY--The removal of snow is sometimes a serious matter in Berlin, snow storms sometimes taking place which have many of the features of the worst so-called blizzards in New York. During the winter of 1906-07 there were 410,582 wagon loads of snow removed at a cost of about \$293,000 for carting and \$62,500 for extra labor.

COLOGNE, GERMANY--In this city there are eight cleaning districts each divided into eight subdistricts. Each of these snow districts has a foreman appointed for the force of regular laborers and extra workmen are employed. Four wagons for hauling away the snow are assigned to each gang. In all there are 56 snow districts. The work is begun simultaneously on the principal streets. After this the other streets are freed from the snow in regularly prescribed order.

The wages of the extra men are 7 cts. per hour, which is very much cheaper than men can be hired for in this country. The removal of 1000 cu.yds. of snow costs about \$84. Most of the snow is dumped into the Rhine. There are seven dumping places on the wharves and seventeen elsewhere.

HAMBURG--The method of subdivision into districts is much the same as in Cologne. The snow is first removed from the sidewalks in front of private houses, business places and unoccupied lots. At the same time the snow is removed from the street car tracks to keep them in working order. Meanwhile snowplows and sweeping machines work day and night to remove

snow from the center of the streets to the curbs, where it is piled up and removed.

LONDON, ENGLAND--Snow is removed as far as practicable by the use of salt. Common rock salt of a brownish color, resembling coarse sand is stored in bins at convenient points along the streets and is sprinkled on the streets like gravel on the approach of snow. When the snow falls, it rapidly melts on this saline bed and runs off to the sewers. If the snow continues for a long time and does not melt promptly more salt is used, until the mass becomes a sloppy, semi-liquid compound which can be flushed into the sewers with a hose. Only rarely is it necessary to resort to carts to haul the snow away. In 1905 there was so little snow that no special attention had to be paid to it. It is estimated that one ton of rock salt is enough for 16,000 sq.yds. of roadway per six inches of snow.

CONCLUSION.

It is hoped that the information above given will serve as a guide to the right principles and practices in this branch of sanitation. It would have been well to have been able to have deduced some principles of general application, especially as to efficiency and cost, but the nature of the work and the character of the information available does not admit of many precise deductions of this kind. Numberless conditions of pavement, of traffic and of weather, besides different sanitary methods, make it impossible to treat this subject as carefully as other engineering subjects.

In order to obtain the best efficiency in street cleaning, the author cannot give better advice than that obtained in the following rules taken from George A. Soper's Modern Methods of Street Cleaning:

"The following are a number of points which go far to account for good results in Europe. Most of these points have a general application to American conditions:

(1) Centralization of responsibility for the repair and cleaning of street pavements is desirable.

(2) A competent person should be at the head of the street cleaning department--preferably an engineer experienced in sanitary work.

(3) An organization somewhat military in character is best. But it is unnecessary that the military spirit should be carried beyond the point required to fix the responsibility and

insure a proper execution of orders.

(4) Good pavements in good repair are indispensable to efficiency and economy in street cleaning.

(5) Asphalt is the easiest pavement to clean, but the hardest to keep looking well because it will not hide dirt.

(6) It is possible to clean streets without the use of water, but the results are only measurably satisfactory in most instances. For the best work there should be sufficient water used to carry off the finer dust by the use of water from a hose preceded by thorough lubrication with water from a sprinkling cart.

(7) Sewers should be used to carry away all street refuse and sand which can be put into them without obstructing them or adding seriously to the problems connected with the disposal of the sewage.

(8) Economy demands that refuse be removed as soon as possible after it is produced and unnecessary littering prevented."





